

Study protocol to determine the effects of solvents on lung function among paint industry workers in Mauritius: A cross-sectional study

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Abstract

Background: The effects of exposure to solvents in paints have been widely studied, but very little information is at hand with only a small number of studies carried out on pulmonary function of paint industry workers. The aim of this study is to determine the respiratory effects of exposure to solvents among workers of the paint industry in Mauritius.

Design and methods: A quantitative cross-sectional study will be conducted in three paint factories across Mauritius. 388 participants would be selected using simple random sampling and be subjected to a pre-designed questionnaire for data collection. Lung function test using a spirometer will also be conducted. Data analysis will be performed using Statistical Package for Social Sciences (SPSS v26.0). The exposed workers will be classified by shift duration, that is, individuals with weekly solvent exposure of ≤ 12 and > 12 h respectively. Using multivariable regression analysis, odds ratio will be calculated to analyze the relationship between the dependent variable (hours of exposure to solvents) and independent variables while adjusting for socio-demographic factors. Independent *t*-test will also be used to identify any difference between the means of lung function tests and the two exposure groups. Based on pre-observation in the three paint industries, it is anticipated that male workers could be found less likely to be exposed to solvents as compared to female workers. Also, workers with a level of education below secondary and lower secondary categories could have a higher likelihood of being exposed ≤ 12 h/week shift. Those who are aware of occupational hazards and could indicate to have used personal protective equipment (PPE) could be less likely exposed to solvents.

Expected Impact of the study for Public Health: This study has been approved by the Ethics Committee of the Faculty of Health Sciences at the University of Johannesburg- ethics clearance number: REC-919-2021. The results of this study will be made available to all stakeholders involved in Health and Safety in the Mauritius. Meetings with professional in the field, especially the concerned paint factories, have been arranged to discuss the impact of solvent exposure and propose remedial actions to protect the workers.

Keywords

Solvents, paint industries, occupational lung disease, PPE, occupational hazard, spirometer, lung function test, Mauritius

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Key message: Studies have shown that exposure to solvents result in health induced outcomes in the auditory, central nervous, hepatic, renal and respiratory systems. This study aim to categorize exposure on the type of work performed, and hypothesis to find the highest exposed group in the production unit and those between 10 and 16 years of employment. Also, it is hypothesized that height and FEV1/FVC ratio for the two exposure groups could yield significantly different results. Participants who used PPE incorrectly were could show a reduced lung functioning ability.

Introduction

The most important component of paints is solvents. Their use include dilution into a proper consistency and viscosity

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for easy handling during manufacturing and application,¹ The main route of entry of solvents into the body is through inhalation, accidental ingestion and skin absorption,² Solvents have been shown to affect critical systems in the body; auditory system,³ central nervous system,⁴ hepatic system,⁵ renal system,⁶ and respiratory system.⁷ Exposure through inhalation is most common in many occupational scenarios and Bahadar et al.⁸ have noted a dearth of literature on the effects of solvent exposure on the respiratory system. Study in a shoe factory suggested an increased risk of pulmonary disease due to occupational exposure to solvents,⁹ Another study noted spirometry changes of bronchial obstruction of a mild degree within 17% of participants.¹⁰

During solvents-dilution process, there is an increased risk of uptake of the solvents concentration. The paint industries on the island employs nearly 1000 workers and the effects of solvents on their health have not been documented in the literature. The cases of occupational respiratory illnesses in Mauritius has been rising during the past 5 years,¹¹ particularly in the paint manufacturing industries, with no exposure assessment been carried out on solvents.¹² There is a significant need to determine the effects of solvents on the lung function of paint workers in Mauritius. In order to address this challenge, this study will pursue the following objectives:

1. To evaluate the relationship between exposure and lung functioning ability among Mauritian paint workers exposed to solvents.
2. To determine the relationship between the risk factors and reactive pulmonary effects among paint factory workers in Mauritius.
3. To assess the use of protective equipment by workers in paint industries in Mauritius.
4. To evaluate the awareness of workers about possible hazards in their workplace.

Materials and methods

The cross-sectional study will be conducted among 388 workers in three selected paint factories in Mauritius. Two exposure groups will be compared; those exposed to solvents for ≤ 12 and > 12 h shift in a workweek, to estimate the magnitude of association between the exposure and outcome. There are only five companies responsible for paint manufacturing in Mauritius and they are located in Pailles, Coromandel, Baie du Tombeau, La Tour Koenig and Camp Fouquereaux. Using convenience-sampling method, only three companies, which lies within a seven-kilometer radius of the capital city, Port Louis, were selected to be part of the study. There are approximately 200 workers in the Sofap Ltd,¹³ 90 workers in Polytol Paints Ltd,¹⁴ and 260 workers in Mauvilac Ltd.¹⁵ A multi-stage sampling method was used to select the 388 participants from the list provided by the Human Resource Departments. Clusters of

workers with previous respiratory symptoms and those without symptoms were formed. Out of these clusters, workers were selected through the stratified random sampling technique as those in the manufacturing process and those performing administrative work. Workers from these clusters were then chosen using a simple random method to make up the desired sample size, thus having a fair representation of different departments and various exposure rates giving a more precise estimate of the whole population. EPI INFO version 7 statistical software Stat-Calc. program was used at a confidence interval of 95% and a minimum detectable odds ratio of 2.0 to determine the sample size. A sample with two exposure groups ratio 1:1 contained 173 for ≤ 12 h and 173 for > 12 h; 10% non-response rate was added for both exposure groups. A total of 384 study participants (194 for ≤ 12 h and 194 for > 12 h) were calculated to be included in the study.

Data collection

A researcher-administered questionnaire will be used to screen participants with/without chronic diseases and possible exposures. In Mauritius, the Occupational Safety and Health Act 2005 stipulates that an employer should conduct medical surveillance regularly for their employees¹⁶ and records should be kept by the Human Resource Department. These reports will be accessed after receiving the participants' informed consent and helped to exclude those with underlying conditions. Participants not suffering from any chronic conditions were further assessed by physical examination. Spirometry test was conducted when all the conditions for a proper test were met. In case of the contrary, the test was postponed until it has been acceptable. Figure 1 presents factors considered for those included and excluded to participate in the study.

Inclusion criteria

The first exposure group will be defined as workers who had chronic respiratory symptom(s) within 1-year period in the paint factory from the time of data collection and/or reduced Forced expiratory volume in 1 s (FEV1), Forced vital capacity (FVC) or FEV1/FVC ratio. The second exposure group will be factory workers who had no chronic respiratory symptom(s) in the same period and normal spirometry readings. A structured respiratory symptom questionnaire and spirometry tests will be used to identify exposure groups.

Exclusion criteria

Workers having work experience of below 1 year will be excluded from the study. Workers who prefer not to participate will also be excluded. Those suffering from severe chronic diseases, excluding respiratory symptoms, such as cancer, on dialysis or cardiac complications will not be

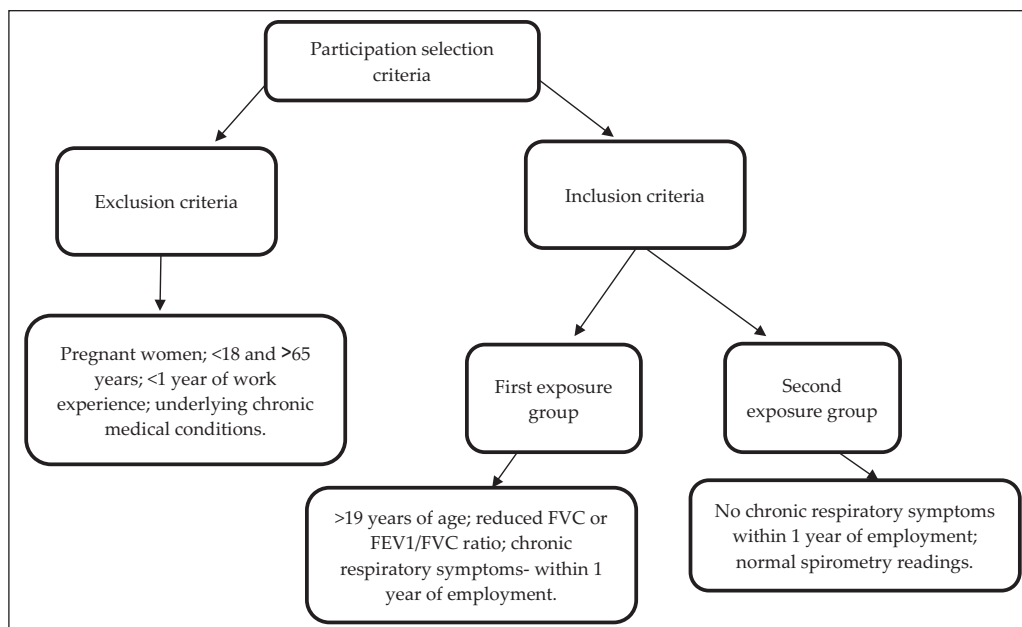


Figure 1. Study selection criteria.

taken in the study. Pregnant women and workers under the age of 18 years and above 65 years old will also be excluded.

Questionnaire

A questionnaire will be filled by the researcher for each participant after obtaining their consent. Apart from the usual demographic history of the participants in the questionnaire, they will be requested to provide their occupation. Their health conditions and lifestyle habits will also be investigated to assess other associated risk factors of decreased lung functioning. Questionnaires are the most commonly used subjective instrument of measurement in respiratory epidemiology and for occupational exposures.¹⁷ The questionnaire was derived from the ECRHS II survey questionnaire after obtaining required permission.¹⁸ Caution will be exercised to ensure that questions are asked in a similar manner to guard against the recall bias.

Spirometry measurements

Physical examination and spirometry test conducted by the researcher (a certified medical practitioner) will be used to assess the lung functions of the participants. Examination of the respiratory system will be carried out for each participant in a private room. FVC and FEV1 are presently the best available functional measures and predictors of respiratory health.¹⁹ FVC is the maximum amount of air expired after a maximum inspiration. FEV1 is the maximum volume of air exhaled in the first second of a forced expiration from a position of full inspiration. Spirometry test is commonly used to detect impaired lung function among

workers exposed to respiratory irritations.²⁰ Guidelines by the European Respiratory Society will be followed to measure the FEV1 & FVC and calculate FEV1/FVC ratio. Three acceptable maneuvers will be taken.²¹

Data analysis

Data on presence of decreased respiratory function among both exposure groups will be compared by calculating the odds ratio (95% CI). Using multivariable regression analysis, crude odds ratio will also be calculated for the groups exposed to solvents during ≤ 12 and > 12 h shift in a workweek. The odds ratio will further be adjusted for the socio-demographic characteristics to determine any significant association between them. Mean and standard deviation of different strata such as age, height, weight and different spirometric readings and ratio will be calculated. Participants with ≤ 12 and > 12 h shift in a workweek will be compared on the basis of the mean of these continuous variables using the independent t-test to find any significant association.

Patient and public involvement

Patients were not involved in this study. Workers in private paint factories were recruited for the study following approval from the management.

Ethics and dissemination

We aim to disseminate the results from the study to the participants, policymakers in the health and paint manufacturing

industries, through presentations and official report. Presentations at conferences and publication of study results will be made in international journals.

This study was granted ethical clearance (REC-919-2021) for non-therapeutic research involving minors from the Faculty of Health Sciences Research Ethics Committee (REC) and Higher Degrees Committee (HDC) of the University of Johannesburg in 2021. Ethical clearance has been noted by the paint manufacturing companies where this study is undertaken. Consent was sought from study participants after understanding that their participation in the study will be voluntary and may choose to withdraw from the study at any time without any repercussion. Research participants' right to privacy was respected and the researcher at all times ensured that all information of participants are securely stored, used and subsequently destroyed to protect the participant's identities. Confidentiality will be maintained through the use of unique identification numbers instead of using participants' names on questionnaires. All the information retrieved from the study will be kept private, confidential and anonymous. No personal details of any participants will be published. After collecting data, questionnaires will be kept in locked cabinets and will only be accessible by the researchers. Collected data in electronic format will be stored on a password-protected computer and retained for 3 years.

Study progress

The study has received ethical approval to commence with the project. The lists of all employee from different sections of the paint manufacturing industries have been received. The researchers are currently busy with data collection and analysis (study ongoing).

Discussion

Based on the observation during walk-through survey undertaken in the three paint industries, we anticipate that male workers with an exposure duration of ≤ 12 h/week could be less likely exposed to solvents as compared to the female workers. The study also anticipate that category of workers (≤ 12 h/week) with the highest level of education; below secondary and lower secondary could be more likely exposed to solvents when adjusting for socio-demographic factors using the degree as a reference. Also, when comparing work departments, participants in the production could be more exposed compared to those in the store departments, using sales department as a reference in the analysis. The exposed group with a duration of employment between 3 and 9 years could be more likely to be exposed to solvents than those with 10–16 years of employment. This could possibly be due to less acquired years of experience working with solvents and less number

of chemical safety trainings undertaken. This study also anticipate that participants (with ≤ 12 h/week) who smoke tobacco and uses PPE (respirators) could be less likely exposed when they are aware of solvents as hazardous. Those who are more likely to provide "YES" as an answer for a question on the presence of local exhaust ventilation at point of solvent use (≤ 12 h/week), using NO as reference, could be more likely exposed to solvents. This might be due to an anticipated protection factor of the local exhaust ventilation and disuse of PPE. Using the answer "seldom" as a reference, participants (≤ 12 h/week) who are likely to answer "constantly" and "never" for the frequency of passing of cars and heavy vehicles by their residence could be significantly less likely to be exposed to solvents. The study also anticipate that participants who sleep with their windows open all the time and work for ≤ 12 h/week could reported to be less exposed to solvents. The significant differences could also be noted between height and the three readings of FEV1/FVC ratio among the two exposed group.

Important changes in the industrial configuration have occurred in the world; new harmful respiratory agents are constantly introduced in workplaces with unknown effects. A study among asthmatics demonstrated that subjects with uncontrolled asthma had substantially higher sickness absence and lower productivity while at work than those with asthma controlled by medication. The presence of psychological suffering at work seemed to increase the effect of asthma on work performance.²² Several studies have been conducted on this subject, with recommendation on how to reduce exposure conditions. Handling of paint in the industry remains an occupational hazard in many aspects, and no studies have been conducted to challenge this occupational concern in Mauritius. In this study, confounders such as smoking, asthma and other risk factors for respiratory problems will be taken into consideration. Exposure to irritant gases and vapors, and its effects have not been sufficiently studied.²³ Synergistic exposures between gases, vapors and solvents in the paint industries where this study will be conducted could present a limitation.

Author contributions

Conceptualization, M.Y.K.Y. and P.C.R.; methodology, M.Y.K.Y. and P.C.R.; writing—original draft preparation, M.Y.K.Y. and P.C.R.; writing—review and editing, M.Y.K.Y. and P.C.R.; supervision, P.C.R.; All authors have read and agreed to the published version of the manuscript.

Declaration of conflicting interests

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Institutional review board statement

The study will be conducted according to the guidelines of the Declaration of Helsinki, and has been approved by the Ethics Committee of the Faculty of Health Sciences at the University of Johannesburg. Ethics clearance number: REC-919-2021.

Informed consent statement

Informed consent will be obtained from all subjects involved in the study prior commencement.

Data availability statement

N/A

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